PHENIX
OPERATION AND MAINTENANCE OF DETECTOR BUBBLER SYSTEMS

procedure name

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LETTER	DESCRIPTION	DATE	AUTHOR	APPROVED BY	CURRENT OVERSIGHT
A	First Issue (formalized from a letter describing the DC bubbler system. To be formatted and rewritten in next revision.)	3/30/2007	R. Pisani	<DRAFT>	R. Pisani

This document is a description of the bubblers that are presently under construction at Stony Brook

A now extensive study of radiation damage and Malter effect on spare nets from the PHENIX drift chamber is nearing completion. The preliminary conclusions are very clear:

1) The west drift chamber materials lead to very rapid aging of the drift chamber wire nets. No net survived more than 10 mC/cm of integrated charge. More typical was a wire death before 5 mC/cm of integrated charge.
2) The east drift chamber materials (mostly new, but re-used cathodes, and V1, V2 layers) lead to aging at a lower but still measurable rate. Typically in this case wire nets withstood ~20 mC/cm.
3) Both ethanol and water bubbling extend the lifetime of the wires in both arms.
    a. Ethanol requires higher voltages to achieve the same gain, but leaves more "head room" prior to the spark point (gaining about 200 V of head room).
    b. Water uses the same voltages as dry gas to achieve gain, but the spark point moves up by about 100-200 V. Additionally, water additives cure the Malter-damaged regions restoring full voltage holding capabilities to previously damaged nets nearly every time.
        i. The net presently under study was damaged and could not hold voltage in dry gas. With water additive, it has been running for 3 weeks with no sparks at more than double the PHENIX operating gain (37,000 vs 16,000) and has received an integrated dose of more than 100 mC/cm.

These observations are consistent with the published literature:

" ... Frequently, it is seen that, when gold-plated wire is used, the addition of small (~ 1%) concentrations of alcohols (ethanol, isopropanol) to a gas that is associated with aging will eliminate or substantially reduce the rate of gain loss. Water vapor (100-1000 ppm) seems also to be effective in this regard, although not so much as alcohols, but it is quite effective in suppressing electrical discharges ... "
" ... Water is effective in preventing the occurrence of large dark currents associated with Malter-type breakdown, but it is also very effective in restoring wire chamber operation after these problems have occurred. The mechanism for the recuperative effects of water is not understood, but it may be that some electrical conductivity of the water aids in discharging electrical charges that have build up on thin insulating films on the cathode. In addition, the water can help in the quenching process since it is effective in absorbing X-rays ... "
" ... A combination which works very well (with gold-plated wire) is Ar/C2H6 (50%-50%) with 1.5 % of ethanol added, by bubbling the gas through the ethanol at 0 C ..."

…quotes taken from `J.Kadyk, Nucl. Instr. Meth. A300, 436-478 (1991)`

Presently, we have a set of east arm nets under gain settings far in excess of the PHENIX running condition (test box gain set at 37,000, PHENIX running gain = 16,000) which have not sparked in three weeks while receiving a gain-related current draw of over 100 micro-amps per wire. This test far exceeds the lifetime of PHENIX in terms of radiation damage and makes us confident that bubbling is the answer to many of the troubles that linger in the west arm (the rebuilt east arm is nearly without troubled regions) will be restored to full operation when we will pre-treat the avalanche gas.

Bubblers operate on the principle that the working liquid will reach equilibrium concentration (partial pressure of liquid = vapor pressure) during the travel of the bubble through the liquid. This process is aided by having the smallest possible bubbles (large surface/volume ratio). The actual concentration of additive is then controlled by taking advantage of the dependence of the vapor pressure of the liquid wrt temperature. In the case of ethanol, a 1.5% additive results from bubbling at 0 C and a 3% additive results from bubbling at 10 C. Stony Brook tests for ethanol have used 1.5%; BRAHMS uses 3%. We require temperature control to roughly 1 C to ensure stable operating conditions of the detector.

An additional consideration is the rate of liquid usage. In the case of water (low vapor pressure) the rate of liquid usage is small and so we have designed with ethanol in mind. At 15 SCFH flow, and 1.5% ethanol concentration we will use 3 liters/week of ethanol in each detector. We set as a design criterion that the user should refill the bubbler at most once per week and that during each week, only a 1 inch drop in the fluid level would be tolerated. Additionally we required that the system be capable of producing this performance with 3% alcohol additive in case we decided to vary this parameter in the future. These requirements specify the surface area of the liquid. The result of the study is that an 18"x18" square box would result in 1" of level drop per week. Later in the design stage, we decided that the bubbler would be easier to manufacture if it were round. With 18" diameter, the fluid level will drop by 1.3" at 3% and .6" at 1.5%.

Since the bubbler will be refilled frequently, we must be able to accomplish this task while data taking is in full swing. Since the temperature of the fluid sets the concentration, we must add "pre-cooled" liquid to the working system. Additionally, others who have done this (BRAHMS, Leigh Hawkins) will pre-condition the fluid by bubbling either pure Ar or working gas through it prior to its introduction into the running bubbler. We have chosen the former to minimize the distribution of flammables throughout the system (the only flammable introduced into the refill reservoir will be the working fluid itself as we will condition with Ar).

To summarize the design requirements:

1) Small bubbles for concentration saturation
2) 18" diameter tank for each arm.
3) Temperature control of the operating fluid in the range 0-10 C with 1 C stability.
4) On-the-fly refill system
5) Preconditioning (temp and gas) of the refill fluid

To achieve small bubbles and reduce material contamination, we chose a ceramic diffuser called "micro-bubble" which gives the smallest bubbles I have seen (a "white mist" in water and under 1 mm in ethanol). We performed extensive studies using these diffusers and have found that they have a non-negligible pressure drop and that the pressure drop across a single bubbler at full flow varies from 30 to 60 inches of water depending upon whether they have been sitting and thereby clogging the hole with fluid. By placing 8 of these in parallel we keep the pressure drop below 10 inches of water thereby ensuring that the system will be able to drive them effectively.

The diffuser head is constructed with an array of 8 ceramic diffuser tubes arranged as radial spokes around a central hub. Each tube is 4” long and the overall diameter of the diffuser head is 9”. The tubes are held in place using DP460 epoxy, the same as in the chamber.

Each bubbler tank is made from a SS tube welded top and bottom to ½” SS plates. Attached to the sides of each bubbler are one drain port and one level gauge to view the depth of the liquid during operation and refill. The top plate of the bubbler tank has one port for filling from the reservoir and a large hole for the immersion assembly/flange. All fittings except the fill port are on the flange. The tank is insulated from the room by 2” of blue foam insulation. The blue foam is hidden from view by a sheet aluminum box.

The flange assembly contains all plumbing connections and need not be opened during normal operation. The cooling tube is a 10 inch diameter cylinder of ¼” SS tubing which was manufactured commercially. It is brazed to the lid and positioned so that the coil portion will be below the surface of the fluid. The diffuser head is also brazed to the lid as is the exhaust pipe. One additional port for an immersion temp gauge will be installed onto the lid so that as a future upgrade we can measure the temp of the fluid directly. The flange is attached to the lid by a bolt ring and the seal is made with a viton O-ring.

The reservoir is a commercially manufactured pressure–driven fluid dispenser. It is rated for 130 psi and has a welded SS wall. The unit has 4 ports, one of which (the dispenser port) is linked to a tube that reaches the bottom. Additionally, there is a large port used for filling that is removable and re-seals with an O-ring. We will solder a cooling coil to the exterior of this vessel that will allow us to cool the contents prior to refill. The 4 ports will serve the following functions:

1) Dispenser port links to both bubblers at their filling point via valves that choose which bubbler is being filled.
2) Port 2 connects to the Ar supply and has a tube that extends below the surface of the bubbler. This port will provide Ar for the conditioning and the pressure necessary for filling the bubblers.
3) Port 3 connects to the vent for use while conditioning.
4) Port 4 will be plugged and available for a temp gauge upgrade.

The normal sequence of operation of the system is detailed in the section below:

Two days in advance of a refill:

1) Close the Ar supply, vent, and bubbler refill valves if they are not already closed (they should normally be closed at this point).
2) Open the large fill port and add fluid to the reservoir.
3) Close the large fill port.
4) Open the vent valve and Ar supply valve.
5) Adjust the Ar flow rate to desired level for fluid conditioning.

On the day of the refill:

1) Close the vent valve on the now conditioned reservoir fluid.
2) Slowly open the fluid extraction valve to the first bubbler to initiate fluid flow.
3) Continue fluid flow until the level indicator shows the ideal level then close the fluid extraction valve.

4) Repeat steps 2,3 for the second bubbler.
5) Close the Ar supply valve to the reservoir.
6) Briefly open the vent valve on the reservoir to relieve its pressure, and then close it.

This sequence of steps will ensure that the alcohol introduced into the working bubblers is at the operating temperature and has had gaseous components (other than Ar) removed. This is what is meant by “conditioned” fluid. The conditioning step also removes the head of air in the reservoir tank that exists just after adding fluid to it.

Upon first introduction of the bubbler into the system, one must additionally purge the bubbler system. This is a one-time procedure. To initially purge the main bubblers, they and the reservoir should be devoid of fluid. Follow the refill procedure, which will introduce pure Ar at a measured flow into the vessels instead of fluid. Bleed the Ar by loosening the swagelok connection from the supply side of the bubbler. Flow for roughly 10 turns of the bubbler volume and seal the system. After this, follow the normal “on the day” refill procedure to bring the bubblers to the desired level.